

CLAIMS

What is claimed is:

- 1 1. A method of correcting for a tilt in a mammogram, the method
2 comprising:
 - 3 classifying pixels as either likely fat or likely not-fat;
 - 4 identifying a candidate tilt; and
 - 5 calculating a histogram of the likely fat and the likely not-fat pixels at the
6 candidate tilt; and
 - 7 evaluating a quality of the candidate tilt based on features of the
8 histograms of pixel values in the fat and the dense tissue classes.
- 1 2. The method of claim 1, wherein evaluating the quality of the
2 candidate tilt based on the features of the histograms comprises:
 - 3 evaluating a quality of the candidate tilt based on a skew and variance of
4 the histograms.
- 1 3. The method of claim 2, wherein evaluating the quality of the
2 candidate tilt comprises calculating a weighted Mahalanobis distance between
3 the likely fat and the likely not-fat distributions to determine a quality of the
4 candidate tilt.
- 1 4. The method of claim 3, wherein evaluating the quality of the
2 candidate tilt further comprises giving more weight to the variance of the fat
3 distribution in the weighted Mahalanobis distance calculation.

1 5. The method of claim 3, wherein evaluating the quality of the
2 candidate tilt further comprises using the skewness of the fat histogram to give a
3 preference to distributions that are not skewed to the negative side.

1 6. The method of claim 3, wherein evaluating the quality of the
2 candidate tilt further comprises adjusting the result to favor smaller tilts.

1 7. The method of claim 3, wherein evaluating the quality of the
2 candidate tilt comprises applying the equation:

$$D(p_x, p_y) = \frac{m_d - m_f}{\sqrt{(0.7 \text{ var}_f + 0.3 \text{ var}_d)}} + 0.5 \text{inf}(0, skew_f) - 0.1|p_x| - 0.1|p_y|$$

1 8. The method of claim 1, wherein identifying the candidate tilt
2 comprises identifying a first set of candidate tilts, based on an expected tilt
3 distribution.

1 9. The method of claim 8, further comprising identifying a subsequent
2 set of candidate tilts, based on the best tilt identified in a previous iteration, to
3 provide more accurate tilt.

1 10. The method of claim 1, wherein classifying pixels as either likely fat
2 or likely not-fat comprises:
3 generating a smoothed image;
4 subtracting the smoothed image from an original image; and
5 determining whether pixels are convex to classify the pixels as likely not-
6 fat, or concave to classify the pixels as likely fat.

1 11. The method of claim 10, wherein the pixels are classified
2 individually.

1 12. An apparatus to correct a tilt in a mammogram comprising:
2 a dense/fat classifier to classify pixels as either likely fat or likely not-fat;
3 a candidate tilt identifier to identify a candidate tilt; and
4 a histogram creator to calculate a histogram of the likely fat and the likely
5 not-fat pixels at the candidate tilt; and
6 a tilt quality evaluator to evaluate a quality of the candidate tilt based on
7 features of the histograms of pixel values in the fat and the dense tissue classes.

1 13. The apparatus of claim 12, wherein the tilt quality evaluator uses a
2 skew and variance of the histograms to evaluate the tilt quality.

1 14. The apparatus of claim 13, wherein the tilt quality evaluator further
2 comprises a Mahalanobis calculator to calculate a weighted Mahalanobis
3 distance between the likely fat and the likely not-fat distributions to determine a
4 quality of the candidate tilt.

1 15. The apparatus of claim 14, wherein the tilt quality evaluator further
2 comprises a quality calculator to give more weight to the variance of the fat
3 distribution in the weighted Mahalanobis distance calculation.

1 16. The apparatus of claim 14, wherein the tilt quality evaluator further
2 comprises a quality calculator to use the skewness of the fat histogram to give a
3 preference to distributions that are not skewed to the negative side.

1 17. The apparatus of claim 14, wherein the tilt quality evaluator further
2 comprises a quality calculator to adjust the result to favor smaller tilts.

1 18. The apparatus of claim 14, the tilt quality evaluator evaluates the
2 tilt quality using the following equation:

$$D(p_x, p_y) = \frac{m_d - m_f}{\sqrt{(0.7 \text{ var}_f + 0.3 \text{ var}_d)}} + 0.5 \text{inf}(0, skew_f) - 0.1|p_x| - 0.1|p_y|$$

1 19. The apparatus of claim 12, wherein the candidate tilt identifier to
2 identify a first set of candidate tilts, based on an expected tilt distribution.

1 20. The apparatus of claim 19, the candidate tilt identifier further to
2 identify a subsequent set of candidate tilts, based on the best tilt identified in a
3 previous iteration, to provide more accurate tilt.

1 21. The apparatus of claim 12, wherein the dense/fat classifier
2 comprises:

3 a smooth image generator to generate a smoothed image;
4 a delta calculator to subtract the smoothed image from an original image;
5 and
6 a pixel classifier to determine whether pixels are convex to classify the
7 pixels as likely not-fat, or concave to classify the pixels as likely fat.

1 22. The apparatus of claim 21, wherein the pixels are classified
2 individually.

1 23. An apparatus comprising:
2 an image receiver to receive a digitized mammogram image, the digitized
3 mammogram image representing a mammogram taken with non-parallel
4 imaging plates;
5 a tilt corrector to evaluate a plurality of candidate tilts designed to correct
6 for the non-parallel imaging plates;
7 an image adjustor to adjust the digitized mammogram image in
8 accordance with a best candidate tilt; and
9 an output mechanism to output the corrected mammogram image, the
10 corrected mammogram image used for computer aided diagnosis to detect
11 abnormalities in the corrected mammogram image.

1 24. The apparatus of claim 23, wherein the tilt corrector comprises:
2 a dense/fat classifier to classify pixels as either likely fat or likely not-fat;
3 a candidate tilt identifier to identify a candidate tilt; and
4 a histogram creator to calculate a histogram of the likely fat and the likely
5 not-fat pixels at the candidate tilt; and
6 a tilt quality evaluator to evaluate a quality of the candidate tilt based on
7 features of the histograms of pixel values in the fat and the dense tissue classes.

1 25. The apparatus of claim 24 wherein the tilt quality evaluator
2 evaluates the quality of the candidate tilt based on a skew and variance of the
3 histograms.